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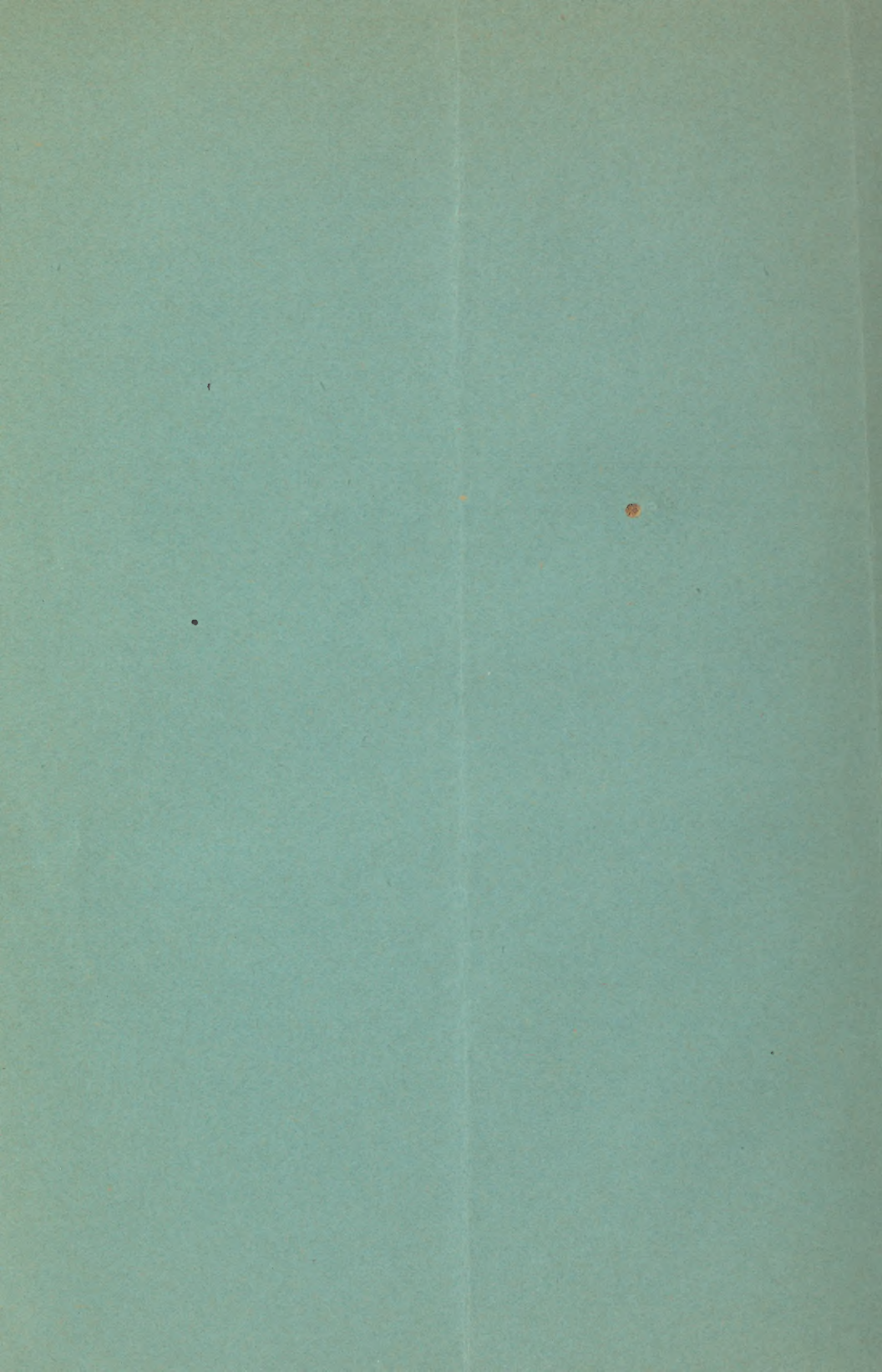
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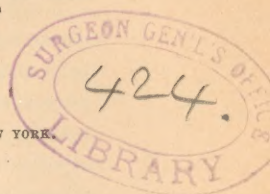
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THE ANATOMY AND PHYSIOLOGY OF THE FAUCIAL TONSILS
WITH REFERENCE TO THE ABSORPTION OF
INFECTIOUS MATERIAL.¹

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ALTHOUGH very much has been said and written about the diseases of the tonsils, but little attention, comparatively, has been given to their normal structure and to the rôle which they play in the animal economy.

The descriptions of their minute structure in most text-books of anatomy and histology, and even in special treatises on the throat and nose, are exceedingly meagre. This would account in part, at least, for the considerable diversity of opinion which exists concerning their pathological conditions. We have little definite knowledge of their functions. Certain theories have been propounded, but none have been sufficiently conclusive as to have lead to any very general acceptance.

In view of this these studies are presented. They have involved the examination of a large number of tonsils, both human and from some of the lower animals, *i. e.*, dog, cat, rabbit, monkey, and raccoon; and they include the results of a considerable number of original physiological experiments.

The tonsils belong to the lymphatic apparatus; and in order to make the description of them more intelligible, it seems wise to review the structure of the better known lymphatic organs before describing the tonsils in detail.

The structures of the lymphatic apparatus may be classified, on an anatomical basis, in three groups.²

1. The simplest form of these structures are the minute masses, consisting of connective tissue, reticulum, or basement-substance, the meshes of which are filled with small spheroidal cells. These structures,

¹ Being the Alumni Prize Essay of the College of Physicians and Surgeons, New York, 1890.

² The spleen seems to belong more properly to the hæmatopoëtic rather than to the lymphatic system.

which were first described by Arnold,¹ are found scattered in many of the viscera, *i. e.*, lungs, liver, and kidneys. The reticulum is exceedingly fine and delicate, and is lined by endothelium. The spheroidal cells are about the size of or somewhat larger than leucocytes, and may contain one or more nuclei. The masses are not clearly outlined, but gradually merge into the surrounding tissues.

2. Of more complex structure are certain nodules of lymphoid tissue occurring in the walls of the stomach and intestine, the so-called "solitary and agminated follicles or glands." Inasmuch as they are in no respect either follicles or glands, they are more properly called lymph nodules. The solitary nodules are little pear-shaped masses lying principally in the submucosa, and are composed of a reticular network, whose meshes are more closely arranged about the periphery. The meshes are lined with endothelium, and are filled with lymphoid cells. In the periphery is a rich network of bloodvessels and lymphatics. The bloodvessels send but a few branches into the more central portion of the nodule. They lie beneath the epithelium of the gut, through which lymphoid cells constantly pass. The epithelial covering is oftentimes thinned and excavated by pressure of the nodule upon it. Peyer's patches, or the agminated nodules, are aggregations of a number of these masses.

3. The most complex of the lymphatic structures, so complex, indeed, as fairly to merit the term organs, are the lymph nodes, often incorrectly called lymph glands. These are oval or irregular-shaped bodies, which interrupt the passage of lymph through the lymph vessels. They are surrounded by a fibrous tissue capsule, which furnishes numerous trabeculæ to the interior. In the outer or cortical zone are a large number of lymph nodules furnished with cord-like anastomosing bodies, which ramify the inner or medullary portion, the lymph cords. The nodules and cords are composed of the same sort of tissue as are the lymph nodules of the intestine, except that their surfaces are covered by endothelium. Both are surrounded by a coarser reticular network containing a few lymphoid cells, the lymph sinuses. The bloodvessels, except the few branches supplying the connective tissue, ramify in the lymph cords and lymph nodules, while the lymph circulates in the lymph sinuses.

The tonsil corresponds more nearly in structure with a Peyer's patch.

GROSS ANATOMY OF THE FAUCIAL TONSILS.

The tonsils, two in number, are situated on either side of the mouth, between the anterior and posterior pillars of the fauces, and are more

¹ Virch. Arch., Bd. 80, 82, 83.

or less covered by folds of the mucous membrane. They are of a pinkish color and oval or almond-shaped. Their long axis, when the mouth is widely opened, is nearly vertical. When the mouth is closed they tend to approach one another, the long axis being more nearly horizontal. Externally they are covered by a layer of fibrous tissue derived from surrounding parts, and which serves as a partial investing sheath. They are covered by the superior constrictor muscle, which separates them from the internal carotid arteries. The internal or free surface projects into the cavity of the mouth; it is covered by stratified squamous epithelium, continuous with that of the mouth. In size the tonsils vary considerably at different ages, and in different persons of the same age. According to Sappey¹ their average vertical measurement is from 20 to 25 mm.; antero-posterior, 12 to 15 mm.; transverse, 10 to 12 mm. As a rule, they are relatively larger in childhood, as is the case with the rest of the lymphatic apparatus.

They reach their maximum size in early adult life. They afterward tend to atrophy, and in old age may become almost entirely obliterated, or converted largely into fibrous tissue.

They are composed, in general, of an aggregation of lymph nodules, separated from one another by diffuse lymphoid tissue, and arranged about a series of depressions from the surface, from eight to fifteen in number, the crypts. These crypts are lined by epithelium similar to that on the surface.

BLOOD-SUPPLY.—The following arteries supply the tonsils:

1. Branches from the dorsal artery of the tongue.
2. Branches from the inferior palatine from the facial.
3. Branches from the superior palatine from the internal maxillary.

The veins empty into the internal jugular. The nerves are, principally, from the glosso-pharyngeal; also branches from the pneumogastric, and possibly also from the spinal accessory (Balme).²

The lymphatics will be considered in the description of the minute anatomy.

ANOMALIES.—But few cases of malformation of the tonsils have been reported. They may be entirely absent (Salmuth³), or, but partially developed, as in a case reported by Gould,⁴ in which there was also faulty development of other organs. There may be an accessory tonsil (Jurasz⁵ and Claiborne⁶).

¹ Anatomie descriptive.

² De l'Hypertrophie des Amygdæles, Paris, 1888, p. 14.

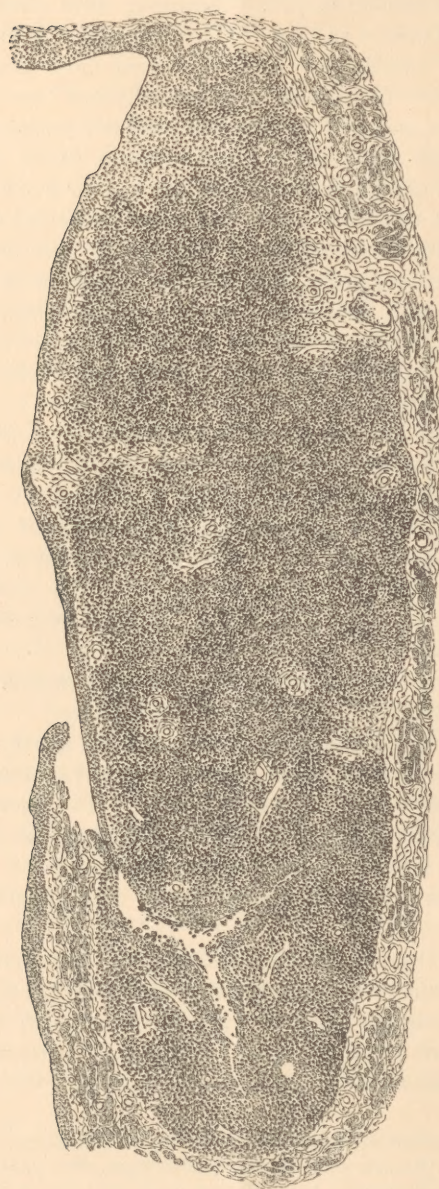
³ Handb. d. path. Anat., Halle.

⁴ Brit. Med. Journ., Oct. 16, 1886.

⁵ Monatschrift für Ohrenh., 1885, No. 12.

⁶ N. Y. Med. Journ., Feb. 8, 1890.

FIG. 1.



Drawing from a section of a normal tonsil from a child.

The development of the tonsils has been described by Kölliker¹ and Bickel,² and more recently exhaustive studies on the embryology of these structures, both human and in animals, have been made by Retterer.³ According to Retterer, the tonsils develop both from the epiblast and the mesoblast; the lymphoid cells being formed from the epiblast, while the bloodvessels, lymphatics, and connective framework come from the mesoblast.

They first begin to appear in man about the fourth month, and first consist of a collection of small spheroidal cells in the submucosa; at first the collection is diffuse, but gradually becomes more circumscribed. After a time the collection of cells becomes subdivided by numerous connective-tissue septa.

At the fifth month depressions in the mucous membrane begin to appear. These are the crypts, and at first consist of solid plugs of cells dipping down into the submucosa and into the collection of lymphoid cells. Later these become hollow. In the early months the mucous membrane covering the tonsil has a distinct membrana propria, but toward the end of gestation this disappears. At term the tonsils are fully formed.

HISTOLOGY.

The parts to be described are as follows:

1. The reticulum or stroma.
2. The cells.
3. The bloodvessels, lymphatics, etc.
4. The epithelium.

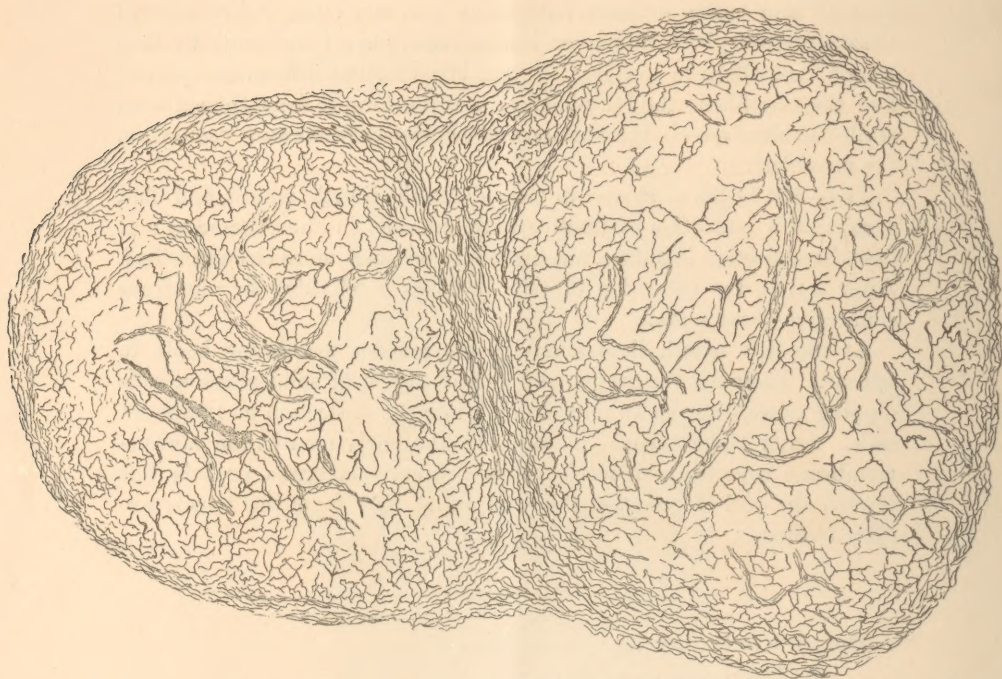
1. THE RETICULUM.—The external or attached surface is covered by a layer of fibrous tissue derived from surrounding parts. From this partially investing sheath numerous septa are given off, dividing the tonsil into a series of intercommunicating chambers. The reticulum or framework in which the cells lie closely packed is of two kinds. A, that which is found in the nodules; and B, that which forms the stroma of the tissues between them. (Fig. 2.) The reticular tissue of the nodules is exceedingly fine and delicate. (Fig. 3.) The meshes are lined throughout by endothelium. About the centre the meshes are large and irregular, but toward the periphery they become somewhat coarser and more closely arranged, and finally become merged into the relatively coarser reticulum between the nodules. This form of reticulum contains no connective-tissue cells, and although it is usually

¹ Embryologie, 1882.

² Arch. für path. Anat. und Phys., xcvii. p. 340.

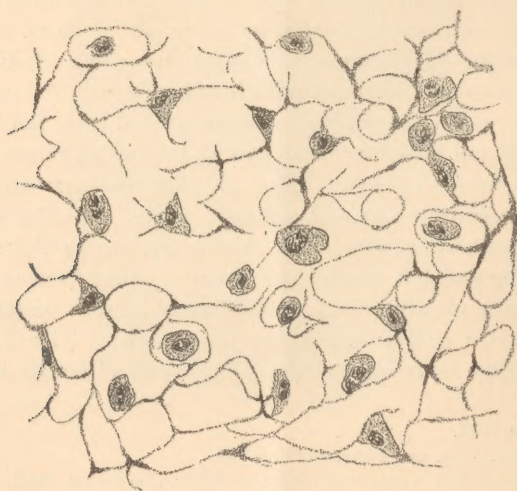
³ Journ. de l'anat. phys., etc., Paris, 1888, pp. 1-80; also Compt. rend. Soc. de Biol. Paris, 1886, pp. 536 and 581; also vol. iii. p. 27.

FIG. 2.



A drawing from a section of a normal tonsil from which the cells have been removed, showing the reticulum of two nodules.

FIG. 3.

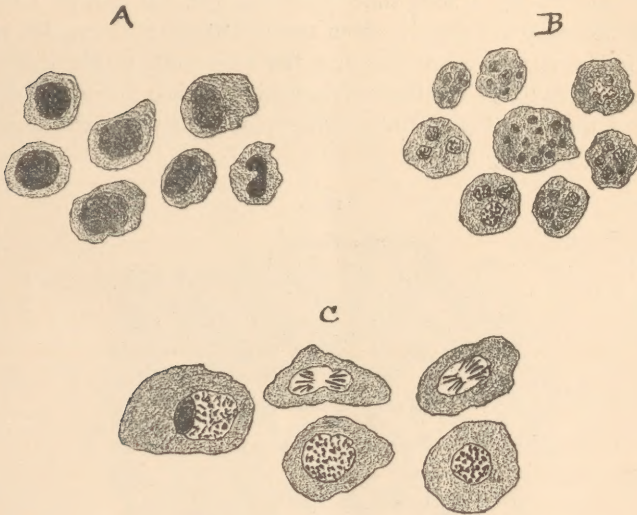


High-power drawing, showing the reticular tissue of a nodule.

described as being composed of connective tissue, it seems more properly to belong to a different variety of tissue. It may be called reticular tissue in contradistinction to the connective-tissue reticulum between the nodules. This last-mentioned form of reticulum differs from that just described, in that it is evidently derived from the fibrous-tissue septa. It is coarser and more closely arranged than the reticular tissue of the nodules, but the meshes are lined by endothelium. About the periphery the varieties merge into one another.

2. THE CELLS.—Three varieties of lymphoid cells, which almost completely fill the reticular network, may be distinguished. (Fig. 4.)

FIG. 4.

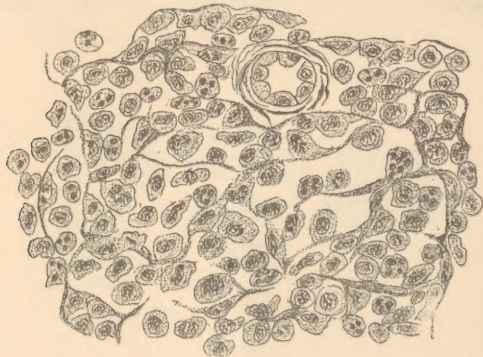


The cells which occupy the reticular network.

A. The majority of the cells are of a spheroidal or irregular shape from 5 to 8 μ in diameter, containing a single nucleus from 2 to 4 μ in diameter. The nuclei are either of a homogeneous or finely-granular character, and occasionally contain vacuoles. No distinct limiting cell-membrane can be detected. B. The cells of this group differ from those of the preceding, in that they are multinuclear. The nuclei vary in number from two to four in a single cell. These closely resemble leucocytes, and the relative number of the two varieties differs a good deal in different sections. As a rule, the mononuclear are vastly more abundant than the polynuclear cells. A large number of specimens were carefully examined with reference to cell-division in these

cells; but none was observed in which karyokinetic figures could be satisfactorily demonstrated. Karyokinesis, in lymphoid cells, is still a much-disputed point among histologists. The studies of Baumgarten¹ and Ribbert² seem to confirm those of the writer. On the contrary, Flemming³ and his pupils Drews⁴ and Paulsen,⁵ Peremschko,⁶ Lavodowski,⁷ Stöhr,⁸ and others claim to have observed lymphoid cells in the process of indirect cell-division. C. Large, irregular, flat nucleated cells are found in greater or less numbers in the reticular spaces. In these the protoplasm, which is surrounded by an investing membrane, is granular, the nuclei are relatively large, round, or oval, and sometimes contain nucleoli. The intra-nuclear network is distinct, and often karyokinetic figures can be made out. The origin of these cells was for a long time undetermined. It can no longer be doubted that they are derived from the endothelium lining the reticulum. Under normal conditions, but few such cells within the meshes are usually seen; but in diseased conditions, when increased desquamation of the endothelial lining takes place, they become especially numerous. (Fig. 5.)

FIG. 5.



High-power drawing showing the lymphoid cells and the reticular tissue.

The reticulum forming the framework of the nodules is more closely packed with cells than is that which separates the nodules from one another. Such an arrangement gives to the nodules a denser appearance, but no difference could be detected in the character of the cells

¹ Zeitschr. f. klin. Med., Nos. ix. and x.

³ Arch. f. Mik. Anat., Bd. 24.

⁵ Ibid., Bd. 24, p. 345.

⁷ Virch. Arch., xcvi.

⁸ Ibid., xcvi.; also Ueber die Peripheren Lymphdrüsen, Separat-abdruck aus den Sitzungsberichten in Würzburg, 1883.

² Ziegler's Beiträge, 1889, p. 185.

⁴ Ibid., Bd. 24, p. 338.

⁶ Ibid., Bd. 17.

in the nodules from those between them. As was shown by serial sections the nodules are arranged concentrically about the crypts.

3. BLOODVESSELS (Fig. 6).—The larger trunks after entering the tonsil are surrounded by fibrous tissue sheets derived from the basal capsule. The fibrous tissue about the larger vessels would tend to interfere with their contraction and closure when cut; and this anatomical arrangement seems to afford an explanation for the hæmorrhage which sometimes follows cutting operations involving removal of large

FIG. 6.



Drawing from an injected specimen showing the distribution of the bloodvessels.

parts of the tonsil. The larger trunks rapidly divide into smaller branches, which ramify in the tissue between the nodules. As was shown by injected preparations, the nodules themselves are but scantily supplied with bloodvessels; and these, as a rule, are principally confined to the periphery. Beneath the epithelium in the submucosa the blood is collected in small veins, whence it is returned to the larger veins at the base, and is finally emptied into branches of the internal jugular.

Lymphatics.—Injections of colored gelatin or solutions of nitrate of silver show that the lymphatic network occupies the whole of the tonsillar mass. The lymphatics constitute a series of closed canals in which the lymphoid cells lie, lined by endothelium, and probably they do not open into the reticular connective tissue, either by stomata or open extremities.

From these lymph channels the lymph is collected by several lymph vessels, provided with valves at the base of the organ. These penetrate the basal capsule and connect with the lymphatics at the base of the tongue, which in turn finally enter the lymph nodes at the angle of the jaw, about at the level of the hyoid bone.

Nerves.—The manner of termination of nerve-filaments in the tonsils could not be determined, since repeated attempts to demonstrate nerve-fibres in them failed in each instance. Aside from nerve-filaments supplying the sheaths of bloodvessels, the presence of nerve-fibres has not yet been demonstrated in the other lymphatic structures.

4. *EPITHELIUM* (Fig. 7).—The tonsil is covered on its free surface by stratified, squamous epithelium, continuous with that of the mouth. In the fully-developed tonsil there is no membrana propria separating the epithelial cells from the underlying tissue. It differs in appearance and arrangement in different parts. In places it presents a uniform layer of from eight to twelve cells in thickness, and is arranged in three layers; the cells of the outermost being flat and scale-like, those of the middle polygonal and “spined,” while those of the inner layer are cuboidal in shape. In other parts, while the arrangement of the cells remains the same, the contour is made irregular by projections upward of the submucosa giving an appearance not unlike the rete Malpighii of the skin.

Such is the usual arrangement of the epithelium of mucous membranes in general. The epithelium of the tonsils, however, and also that covering the solitary and agminated lymph nodules of the intestine, present still other appearances, the result of peculiar alterations in the cells themselves. In such situations, the epithelial cells are diminished in size and are very much altered in shape. The cells now become either cylindrical, irregular, spindle- or star-shaped, and many of them are furnished with long, branching processes, which are apparently continuous with the underlying connective-tissue reticulum. Furthermore, little hollow cavities are found in the epithelial layer, usually near the surface. These cavities contain numbers of lymphoid cells and sometimes are closed on all sides; but sometimes they are provided with minute channels leading to the surface, through which lymphoid cells may be seen to pass.

This alteration, which Zawarykin¹ calls a process of “rarefaction of

¹ Zawarykin: *Anatom. Anzeiger*, 1889, No. 15, p. 467.

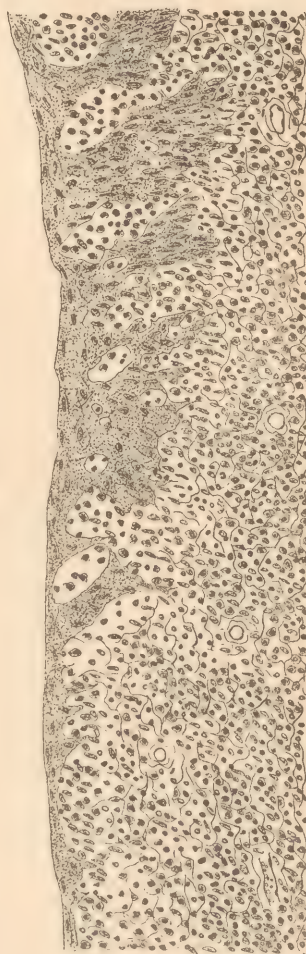
the epithelium," seems to be the result of pressure from beneath upon the epithelial lining. It causes a great irregularity in the contour of the

FIG. 7.



The epithelium covering the tonsil, showing emigration of lymphoid cells and rarefaction.

FIG. 8.



The epithelium covering the tonsil, showing an advanced stage of rarefaction.

epithelial layer, which is also considerably diminished in thickness. In other parts, where these changes have advanced to a still greater degree,

the epithelial covering is so thin as to be but one or two cells in thickness. (Fig. 8.)

"Rarefaction of the epithelium" occurs in both healthy and diseased tonsils. Serial sections show it to be of very irregular distribution; and it has apparently no direct relation with the lymph nodules. As yet its physiological significance has not been made quite clear. It greatly facilitates the passage of lymphoid cells from the tonsil to the cavity of the mouth; and it has, I believe, an important bearing upon the absorption of bacteria and their ptomaines, and in the production of certain of the acute infectious diseases.

The crypts penetrate the substance of the tonsil, generally at right angles to the surface, but sometimes more obliquely. Their number varies from eight to fifteen in a single tonsil. Usually they are single, but they may divide into two or more branches. They vary in depth and in the size of their lumina, and are lined by stratified squamous epithelium. The contents of the crypts consist of emigrated lymphoid cells, desquamated epithelium, granular matter, cholesterine crystals, bacteria, and occasionally particles of food.

In almost every section, a varying number of small spheroidal cells are found between the epithelial cells. As long ago as 1836 "emigration of white blood-cells" was described by Valentin.¹ Since then the process has been carefully studied by a great many observers. Stöhr² has studied this emigration of leucocytes more especially in the tonsils. In all cases, but more especially in tonsils of young persons, a large number of cells similar in structure to those found in the substance of the organ, are continually finding their way through the epithelial covering to the surface or into the lumina of the crypts.

It will be seen, from the above description of the faucial tonsils, that in structure and in the manner of distribution of the bloodvessels and lymphatics, they closely resemble the agminated lymph nodules or Peyer's patches of the small intestine. Except for the crypts, the structure of the tonsils is, indeed, identical with that of a Peyer's patch.

COMPARATIVE ANATOMY.—The tonsils of those animals which were examined were found to be of an essentially similar structure as in the human variety; but in the different species a good deal of difference was observed in their shape and gross appearance.

In monkeys the tonsils differ but little, except in size, from those in man. In dogs, the tonsils are relatively large and spindle-shaped. The long diameter is about four times that of the transverse. The dog's tonsil is folded upon itself, so that it presents a deep fissure, on the surface, which extends from either extremity along the upper and outer

¹ Repertorium für Anatomie und Physiologie, 1836, p. 283.

² Arch. f. Path. Anat. und Phys., xcviii.

aspect of the organ. Into this fissure most of the crypts empty; the few remaining crypts empty on the free surface.

The tonsils are but little encroached upon by the pillars of the fauces; and they are very thoroughly exposed to view when the mouth is opened and the tongue is forcibly drawn forward. Consequently, these animals are especially applicable for physiological experiments.

In rabbits, the tonsils are hemispherical in shape and present a single crypt at the centre, about which the lymph nodules are arranged in rows.

In cats the tonsils are pear-shaped, and lie in a pocket of fibrous tissue in which they are freely movable. Only a small part of the organ protrudes, through a small circular opening in the mucous membrane, into the mouth.

TECHNIQUE.—Specimens, for histological study, are better preserved when treated with corrosive sublimate solution, than are those which have been hardened, directly, in alcohol or in Müller's fluid. Any of the many formulæ of sublimate solution may be employed, of which Lang's is, perhaps, the best, consisting of water 1000 c.c., corrosive sublimate 8 grm., hydric acetate 8 c.c. Small bits of perfectly fresh tissue are placed in this solution. After one hour they are washed in water, and hardened successively in 40 per cent., 60 per cent., 80 per cent., and in strong alcohol. By means of double imbedding in both celloidin and paraffine, exceedingly thin sections may be cut, which, provided all the sublimate has been removed, stain readily in any of the more commonly employed staining reagents.

The reticulum is best studied in sections from which most of the cells have been removed. This may be accomplished in several ways. The most satisfactory way is to make frozen sections from specimens which have previously been hardened for from one to two hours in one-third alcohol. The sections are gently shaken in a test-tube of water, care being taken not to continue the shaking too long. The sections are stained on a slide and mounted on glycerin. The outlines of lymphoid cells are best preserved by teasing a bit of the fresh tonsil in a mixture of equal parts of osmic acid, 1 per cent., and normal salt solution.

None of the methods of demonstrating the lymphatics of the tonsil are altogether satisfactory. Ranvier's¹ method consists in injecting a small quantity of blue gelatin into the substance of the organ just beneath the epithelium, and allowing the specimen to cool before it is hardened in alcohol, and cut into sections. Solutions of nitrate of silver, 1 : 500, are also recommended in place of the gelatin. While this method is applicable with the lymph nodes, in the case of the tonsil it has, thus far, always been the misfortune of the writer to puncture

¹ D^eHistologie. Paris, 1875, p. 674.

some of the smaller bloodvessels with the hypodermic needle, with the result of obtaining a mixed injection. The bloodvessels are easily injected with blue gelatin, artificially through the carotids; or a very good natural injection may be made by suspending the animal before it is killed, by the hind-legs, and hardening the tonsils immediately after they are removed, in strong alcohol.

PHYSIOLOGY.

As has been stated elsewhere, in this paper, our knowledge of the functions of the tonsils is largely theoretical, as nothing seems to have been done thus far by way of experimentation toward the solution of this problem. Indeed, the physiology of the other lymphatic structures, in spite of all the careful research which has been accorded them, is but little understood.

The unsatisfactory state of our knowledge of the functions of the lymph nodes, for example, is well shown by this statement of Foster.¹ "Obviously here, as in the lymphatic follicles of the intestine, the adenoid tissue or lymphatic substance is the seat of an interaction between the blood and the lymph: here the blood gives something to and takes something from the lymph, or, at least, is in some way changed; here the lymph takes from and gives up to the blood. We may be confident that these changes take place, though our knowledge as to the exact nature of these changes is at present very limited."

Studies in pathology indicate that the lymph nodes act as filters. Thus particles of pigment, bacteria, and cells from neoplasms, which have gained access to the lymph channels, are apt to be caught and held in the lymph nodes.

The bronchial lymph nodes succeed, in most cases, in holding back from the general circulation the particles of inhaled pigment which may have been absorbed by the lungs. Living bacteria, or cells from neoplasms, which still have retained vital properties, when they become lodged in the lymph nodes may incite inflammation, or set up new-growths.

It is almost certain that the lymph nodules of the intestines, especially Peyer's patches, are concerned in the absorption of the products of digestion. A certain amount, though but an insignificant proportion of fats, at least, is absorbed by these bodies. (Schäfer.)

The functions of the little masses of lymphoid tissue scattered about in the substance of the thoracic and abdominal viscera are totally unknown.

The studies on the physiology of the tonsils, which I have made,

¹ Handbook of Physiology, London, 1889.

² Journ. Internat. Anat. und Histol., 1885, Bd. ii. p. 16.

were done, more especially, to determine their relations to some of the acute infectious diseases. Before entering upon a discussion of this subject, it will be necessary to consider some of the theories which have been advanced to explain the functions of these organs.

Perhaps one of the oldest of these theories is, that the tonsils are secreting organs, furnishing a thick, viscid mucus which lubricates the bolus of food during the second part of the act of deglutition, and which also lubricates the back part of the mouth and pharynx.

Such a theory is abundantly discredited on purely anatomical grounds. The secretion of mucus is furnished by the numerous mucous glands in the adjacent mucous membrane, and not by the tonsils themselves.

The old idea of Perrin, that the tonsils were concerned in the formation of the voice, seems highly improbable. A connection between the tonsils and the organs of the genital apparatus has been suggested. This notion is more a popular one, and is without scientific foundation.

More recently Hill,¹ Spicer,² and Hingston Fox,³ reasoning from analogy, have advanced the idea that the tonsils reabsorb the waste secretions of the mouth and pharynx. According to these authors, especially the digestive ferments of saliva are absorbed by the tonsils in order to prevent waste. Although this theory did, at first, seem plausible, no attempt was made to strengthen it by actual demonstration.

The physiological experiments which I shall describe later show Hill's theory of the functions of the tonsils to be wholly unsupported by facts.

Recent observations have shown that pathogenic bacteria may be present in the mouths of healthy individuals, often in considerable numbers, and an intimate connection between the tonsils and some of the acute infectious diseases has long been supposed to exist. Moreover, it was thought not to be unlikely that infection, in some cases, may take place through the tonsils.

In order, if possible, to throw some light on this most important problem, I have endeavored to ascertain the amount of absorption which, under favorable conditions, may take place through the tonsils. Experiments were done on dogs and rabbits. In most cases the experiments were repeated, and as far as possible controls were made in each case. The experiments consisted in attempting to cause the tonsils to absorb various materials which could be afterward recognized, microscopically, in the tissues; and according to the nature of the materials used and the manner in which they were applied, the experiments may be divided into several groups.

¹ British Medical Journal, 1888, vol. ii. p. 615.

² Lancet, London, 1888, vol. ii. p. 805.

³ Journal of Anatomy and Physiology, London, 1885-6, vol. xx p. 559.

Landois states that under ordinary circumstances absorption from the mucous membrane of the mouth is very slight, although sufficient is absorbed to enable the sense of taste to be perceived, and applications of powerful drugs may be followed by systemic effects. I verified this statement by applying a solution of atropine to the mouth of a healthy person and watching its effect on the eyes. Although the solution employed was a strong one, and the application continued thirty minutes, and the drug was distinctly tasted, no dilatation of the pupils followed.

1. The tonsils of several animals, as well as the whole of their buccal cavities, were kept constantly smeared with olive oil, in one set of experiments; in a second set, melted lard was used, and in still a third, lanolin. After from fifteen to thirty minutes the animals were killed, and the tonsils, together with portions of the tongue and pharyngeal wall of each animal, were hardened in osmic acid one per cent. and alcohol, and examined microscopically. The epithelial covering of the tonsils contained a few fine, black granules (fat droplets), generally near the surface. The granules seemed to be between the cells. There was no fat, either in the lymphoid cells, or lying free between them. Sections of the tongue and pharyngeal wall from each animal showed a few fat globules in the superficial portions of the epithelial covering.

2. Finely-powdered carmine, Berlin-blue, and emery powder suspended in water, were applied to the mouths and tonsils of dogs, in a similar manner as were the fats.

Microscopical examination in each case failed to demonstrate the absorption of any of the insoluble material in the sections of the tonsils, tongue, or pharyngeal wall.

3. Solutions of anilin colors in water, and in normal salt solution, salts of iron, and strong solutions of atropine, were kept in contact with the mucous membrane of the mouth and tonsils for from fifteen minutes to one hour. In none of the experiments in which colored solutions were employed did absorption, as was demonstrated by microscopical examination of frozen sections, take place.

The tissues which were subjected to the action of ferrous sulphate were afterward placed in a solution of ferric cyanide of potassium. Sections of these specimens failed to show granules of Berlin-blue in the epithelium or in the deeper structures. The dogs to whose tonsils strong solutions of atropine were applied, showed no dilatation of the pupils after the application had been continued for one hour.

4. Solutions of anilin colors and mixtures of insoluble carmine in water were injected beneath the mucous membrane in the neighborhood of the tonsils in different animals, which were killed one hour afterward. In neither case was the coloring matter taken up by the tonsils.

5. A small quantity of a strong solution of atropine (one-sixth gr.) was injected into a dog's tonsil immediately beneath the mucous mem-

brane, care being taken that none of the fluid escaped into the œsophagus. Within a few minutes the pupils became widely dilated, and soon afterward the dog became very drowsy, and finally was unable to stand.

6. Small quantities of both soluble and insoluble pigment were injected into the substance of dogs' tonsils, and the animals were killed one hour afterward. Upon examination the pigment was found to have collected in the spaces between the nodules, where the point of the needle was carried. It showed but little tendency to diffusion. None of the pigment had been gotten rid of by the surface or was found within the crypts.

SUMMARY OF ABSORPTION EXPERIMENTS.

The experiments just described were done with care, and, as far as possible, all sources of error were eliminated. The results seem to show that in healthy tonsils under ordinary conditions:

1. Soluble or insoluble materials are not absorbed by the mucous membrane of the mouth, or pharynx, or by the tonsils, except to a very slight extent.

2. It is the epithelial covering which prevents absorption taking place by the tonsils. Substances in solution which have found their way beneath the epithelium may be rapidly taken up by the lymphatics and carried into the general circulation.

3. Soluble and insoluble foreign materials in the tissues in the immediate neighborhood of the tonsils are not readily and at once taken up by them.

4. Soluble and insoluble foreign materials in the substance of the tonsils are not thrown off by the surface; but may either remain in the tissues or may be carried off by the lymphatics to other parts of the body.

Baumgarten has suggested that the tonsils might be the point of entrance of tubercle bacilli into the body; that tubercle bacilli which may have been taken into the mouth may be absorbed by the tonsils, where they may result in the formation of miliary tubercles. From thence, Baumgarten supposes, infection may spread through the lymphatics to the bronchial lymph nodes and finally to the lungs. In order to determine the relative frequency of tubercular lesions of the tonsils, and to ascertain the relationship, if any, of these structures to pulmonary phthisis, I have examined, microscopically, a large number of tonsils (nearly 200) for evidences of tubercular lesions. These tonsils were from persons of all ages; and they include the tonsils from eighteen persons who died of pulmonary phthisis. In but one case out of the entire number examined were the tonsils tubercular. In this case they were removed from the body of a man who died of very general tuberculosis.

From the results of these examinations it would seem probable that :

1. Tubercular tonsillitis is a rare affection.
2. The tonsils are rarely, if ever, the site of primary inoculation in pulmonary tuberculosis.

Whatever may be the physiological significance of rarefaction of the epithelium of the tonsils, it, together with a knowledge of the nature of the lesions of diphtheria of the tonsils, unquestionably affords a ready explanation of the way in which these structures become infected in this disease. We have seen that rarefaction of the epithelium is of constant occurrence in the tonsils ; that as a result of this process parts of the epithelial covering are very considerably diminished in thickness, not infrequently so decidedly thinned as to be, in certain places, but one or two cells in thickness. Now, as a result of the presence of the contagium of diphtheria, which acts as an irritant to the cells, increased desquamation of the epithelial covering takes place. This proliferation of the cells, as I have actually observed in sections of diphtheritic tonsils, may entirely denude the tonsil of its epithelial covering in places ; and the specific virus of the disease is thus brought into immediate contact with the lymphatics of the tonsils, from whence it is carried into the general circulation.

RECAPITULATION.

1. The tonsils are lymphoid structures closely resembling the Peyer's patches of the small intestine, consisting in general of a congeries of lymph nodules separated from one another by diffuse lymphoid tissue, which are arranged about several hollow depressions of the epithelial covering, the crypts.

2. None of the theories thus far advanced to explain the functions of the tonsils are conclusive.

3. The tonsils produce no physiological secretion.

4. The tonsils are not absorbing organs. They neither absorb fluids or solid particles from the mouth under ordinary conditions, nor do they take up foreign materials from the tissues in their immediate neighborhood.

5. Tubercular tonsillitis is an uncommon affection.

6. There is no evidence to show that pulmonary tuberculosis ever results from absorption of tubercle bacilli from the mouth through the tonsils.

7. Rarefaction of the epithelium of the tonsils affords a ready explanation of the way in which the contagium of diphtheria may gain entrance to the general circulation in this disease.

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